Software Validation and Verification
Fourth Exercise Sheet

Exercise 1

Let ϕ, ψ be arbitrary LTL formulae. Consider the following new operators:

- "At next" $\phi \,\mathrm{N}\, \psi$: at the next time where ψ holds (if it exists), ϕ also holds.
- "While" $\phi \,\mathrm{Y}\, \psi$: ϕ holds at least as long as ψ does.
- "Before" $\phi \,\mathrm{B}\, \psi$: if ψ holds at some point, then it is (either immediately or not immediately) preceded by ϕ.

Make the definitions of these informally explained operators precise by providing LTL formulae that formalize their intuitive meanings.

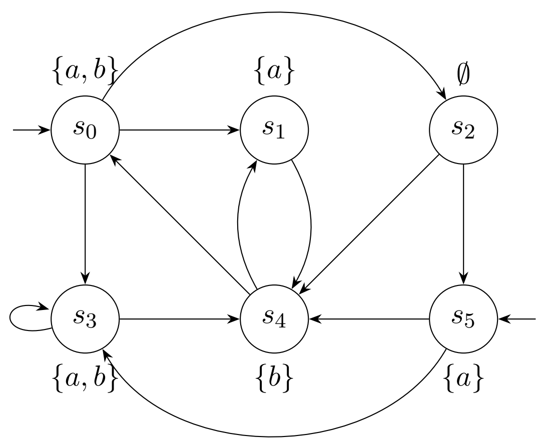
Exercise 2

Let ϕ, ψ, ξ be arbitrary LTL formulae. For each of the following pairs of LTL formulae, determine whether they are equivalent, one of them subsumes the other or they are incomparable.

1. $\Diamond\Box\phi$ and $\Box\Diamond\phi$
2. $\Diamond\Box\phi \land \Diamond\Box\psi$ and $\Diamond(\Box\phi \land \Box\psi)$
3. $\phi \land \Box(\phi \rightarrow \bigcirc\Diamond\phi)$ and $\Box\Diamond\phi$
4. $\phi \,\mathrm{U}(\psi \,\mathrm{U}\, \xi)$ and $(\phi \,\mathrm{U}\, \psi) \,\mathrm{U}\, \xi$

Exercise 3

Consider the following transition system $\mathcal{T}$, for each of the following ϕ_i determine if $\mathcal{T} \models \phi_i$.



$\phi_1 = \Box\Diamond a$

$\phi_2 = \Diamond\Box a$

$\phi_3 = a \rightarrow \bigcirc \bigcirc a$

$\phi_4 = b \,\mathrm{R}\, a$ where $\phi \,\mathrm{R}\, \psi$ is defined as $\neg(\neg\phi \,\mathrm{U}\, \neg\psi)$

Exercise 4

Let $\phi = (a \land \bigcirc a) \,\mathrm{U}(a \land \neg \bigcirc a)$ be an LTL formula over $AP = \{a\}$.

1. Compute all elementary sets with respect to ϕ;
2. Construct the GNBA $\mathcal{G}$ such that $\mathcal{L}_\omega(\mathcal{G}) = \mathit{Words}(\phi)$ returned by the algorithm from the lecture.